BY-CATCH REDUCTION IN THE WHITE SHRIMP, NEMATOPALAEMON HASTATUS FISHERY OF NIGERIA, USING CODEND WITH RIGID SEPARATOR PANEL

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ABSTRACT

Fishing experiments with conventional and modified codends were conducted to reduce fish by-catch from shrimp beam trawl fisheries off Lagos coast, Nigeria. The modified codend consist of Nordmore gride with a guarding panel and bar spacing of 20 mm. Simultaneous paired comparisons against conventional codends showed that the modified codend significantly reduced the by-catch of juvenile fishes up to 72.06% (T-test, $p<0.05;0.01$) with no significant reduction(2.9%) in the quantity of the target shrimps, *Nematopaaemon hastatus* (T-test,$p>0.05;0.01$). Small sized and fusiform shape fishes with total length range of 4 to 10 cm were mostly retained by the modified codend,eg.*Epinephelus aenus* ($p>0.05;0.01$) and *Pomadasys jubelini* ($p>0.05;0.01$) while large and flattened fish specimens with a total length range of 11 to 30 cm were mostly excluded, eg.*Dasyatis margarita* ($p<0.05;0.01$) and *Carcharhinus brachyrus* ($p<0.05;0.01$). The high percentage reduction of the 3 species of most abundance and priortised croaker by-catch family sciaenidae eg. *Pseudotolithus elongatus* (72.73%,$p<0.05;0.01$), *P. senegalensis*(66.65%,$p<0.05;0.01$) and *P. typus* (68.33,$p<0.05;0.01$) makes the BRD a conservation tool for commercial application. The potential of Nordmore gride to alleviate by-catch problem and its limitation in a developing economy is discussed.

Key words: By-catch reduction device, Shrimp, Trawl fisheries, Nigeria

INTRODUCTION

Artisanal beam trawl shrimping in Nigeria is a daily fishery and is carried out throughout the year. The fishery is new and operates using planked canoe powered by 25 or 40 HP outboard engine in estuaries and nearshore part of the sea within 1 to 2 nautical miles from shoreline where their technology could permit. These zones are reserved for small scale fisheries exploitation by the Nigerian fisheries law and regulations and it form the nursery ground for juveniles of fin fishes.Like the majority of trawls, the conventional shrimp trawls typically are poor selective fishing gears and so retain large quantities of non-target species collectively termed 'by-catch'(Saila,1983). By-catch in shrimp trawls became a significant problem for fishery managers who are mandated to maintain sustainable fish stocks when most are fully or over exploited. Shrimps by-catch often includes fin fish species with commercial importance incidentally killed. The mortality of these species is thought to reduce the recruitment, biomass and yield of stocks that form the basis of other fisheries and has been a global concern (Saila, 1983;Andrew and Pepperell,1992;Alverson *et al,* 1994). In 1994, by-catch from shrimp trawls was estimated to be around 11.2 million tones worldwide (Alverson,*et al*,1994).

A recent observer- based study of this fishery that quantified and identified by-catch species and trawling gear components as a pre-requisite for trawling gear modifications to reduce by-catch species showed that;(1.) 25 species belonging to 20 families constituted the by-catch species and are juveniles with a total length range of 4 to 30 cm caught within their nursery grounds, the target shrimp is *Nematopalaemon hastatus* with carapace length range of 0.5 to 1.5 cm

(Ambrose, *et al*, 2005),(2.) the fishing unit is simple; consisting of 7.5 to 9.5 m LOA planked canoes powered by 25 or 40 HP outboard engine, the trawl codend mesh size is 10 mm stretched(Ambrose and Wlliams, 2003),(3.) the croaker family, sciaenidae is the most abundant and priortised by-catch family for reduction(Ambrose,2003).

A global awareness of by-catch problems has led to various management strategies that attempt to alleviate some of the impacts of large by-catches(Andrew and Pepperell,1992). Options such as restricting trawling to locations and times known to have relatively small amount of by-catches(High *et al*, 1969;Caddy,1982) and conversion of by-catch species to human/livestock feed(Peterkin,1982) are to no avail on by-catch reduction. The most applied option throughout the majority of the worlds shrimp trawl fisheries focused on technological changes that involve modifications of conventional trawling gears and methods by incorporating by-catch reduction device (BRD) at the bunt to improve interspecific selectivity and so minimize by-catch of unwanted individuals (Watson *et al*, 1986; Brewer *et al*.,1998;Rulifson *et al*.,1992;Averill,1989;Karlsen and Larsen,1989;Broadhurst and Kennelly1994,1995;Kendall,1995;Isaksen *et al*.,1992). Broadhurst (2000) classified BRDs under two broad categories according to the basic theory and methods used to facilitate the escape of by-catch. The first are those that separate by-catch from shrimps due to behavioural differences. The second are those that separate by-catch from shrimps by size partitioning.In this fishery,juvenile fishes(4-30 cm, TL) and shrimps(0.5-1.5 cm, CL) are exploited (Ambrose *et al*.,2005). The multiple by-catch species are larger than target shrimps and required mechanical separation. Such BRDs comprise of relatively simple oblique panels or grids usually located within or immediately anterior to the codend (Kendall,1990;Andrew *et al*., 1993;Isaksen *et al*.,1992;Broadhurst and Kennelly ,1996) Most BRDs in this category eg. Nordmore grid are designed mainly to exclude those individuals that are larger than the openings in the separating panel.

Our specific goals in this work were to complete a series of experiments under normal commercial fishing conditions to determine the shrimp retention and by-catch exclusion characteristics of Nordmore separation grid inserted in shrimp beam trawl that operates in Nigerian coastal waters.

MATERIALS AND METHODS

The study was performed from October 2003 to January 2004 by 2 men fishing crew with a wooden planked canoe of length overall 8.5 m, powered by 25HP outboard engine.Nearshore Atlantic ocean with depth ranging from 10 to 20 m off Asoroko, south west Nigerian coast(Latitude 6 N to6 30 N and Longitude 3 E to 5 E) was trawled. The beam trawl net used is an improvised stow net rigged effectively for towing, vertical mouth lift, horizontal mouth spread and negative buoyancy.Detailed design and rigging of stow net to bestow for towing is given by Ambrose and Williams(2003). The codends employed for the study measured 454 meshes from anterior to posterior tip, 256 meshes in circumference and were constructed from 10 mm mesh size netting with a thickness of R155 tex. The nets have seven segments joined with a take up ratio of 0.5. Mouth re-inforced panel is thicker(R 470 tex) and mesh size larger(38 mm) to withstand towing stress from the warp and bridles.

Two codends designs were compared. The conventional codend was designed similar to fishers net as described above. The second codend termed' modified codend' have similar design specifications with the conventional codend. It was modified by inserting grid assemblage at anterior codend. It consisted of,(1). 400 mm by 600 mm aluminium grid with a bar spacing of 20 mm,(2). guarding panel net with chain end, and(3) plastic floats

(Fig.1) .The two codends were compared against each other in independent paired trials, that is in separate two hours tows by two adjacent boats fishing at the same time(Thorsteinsson,1992;High *et al.*,1969) on an established shrimping grounds. Over 4 months, We completed a total of 30 replicate tows of each paired comparison.

After each tow in each paired experiments, the two codends were emptied into the midship deck of the canoe. On board sorting of fishes from shrimps started toward shore and was completd upon landing at shore All organisms were sorted according to species and families. The following data were collected from each landing: (1). The total weight of shrimps, (2). The total weight of by-catch in kilogram (3). The weight, number and sizes of commercially important fin and shell fish species were taken using flat head weighing balance and measuring board. Several commercially important by-catch species were caught in sufficient quantities to allow meaningful comparisons. These were; *Pentanemus quinquarius, Galeoides decadactylus, Callinectes amnicola, Ilisha africana, Pseudotolithus elongates, P. senegalenses, P. typus, Cynoglossus senegalensis, Drepane africana, Selene dorsalis, Chloroscombrus chrysurus, Lutjanus dentatus, Arius latiscutatus, Pomadasys jubelini, Trichiurus lepturus, and Carchahinus brachyrus.*

Catch data from all the 30 replicate landings for each of the paired comparison were pooled for analysis. The total weight of by-catch species, target shrimps and the weight and numbers of commercially important by-catch species from both conventional and modified codends were compared. The hypotheses that the weights/numbers of landings (shrimps, total by-catch species and commercially important by-catch species) from conventional and modified codends does not differ were tested using one tailed paired T-test.

RESULTS

Compared with the conventional codend, the modified codend significantly reduced the by-catch of juvenile fishes up to 72.09% (T-test,$p<0.05;0.01$) with no significant reduction(2.9%) in the quantity of the target shrimps *Nematopalaemon hastatus* (T-test,$p>0.05;0.01$, Table 1). Sixteen out of 18 commercially important by-catch species that were caught in sufficient quantity showed high percentage weight reduction (50% and above) in modified codend (Table 2).Small size fishes with total length ranging from 4 to 10 cm were mostly retained by the modified codend, while large fish specimens with a total length range of 11 to 30 cm that could not pass through the grid bar spacing of 20 cm were highly excluded from modified codend (Fig. 2).

The high percentage weight reduction of the 3 species of most abundance and priortised croaker by-catch family, sciaenidae eg *Pseudotolithus elongatus*., (72.73%, T-test,$p< 0.05;0.01$), *P. senegalensis* (66.65%,T-test,$p< 0.05;0.01$) and P. typus (68.33%,T-test,$p<0.05;0.01$, Table 2) makes the BRD a conservation tool for commercial application. Reduction in the number of commercially important by-catch families were significant eg.;clupeidae ($p<0.05;0.01$), trichiuridae ($p<0.05;0.01$) sciaenidae ($p<0.05;0.01$), carangidae ($p<0.05;0.01$), polynemidae($p<0.05;0.01$, Table 3). However, the number of flattened fish species reduced in modified codend were not statistically significant eg. Dasyatidae (T-test, $p>0.05;0.01$) and carcharhinidae(T-test, $p>0.05;0.01$).

The mean catch(kg.) of 13 commercially important by-catch species in modified codend were significantly lower(T-test, $p<0.05;0.01$) than in conventional codend and likewise total by-catch (T-test, $p<0.05;0.01$), while target shrimps was not significant (T-test, $p>0.05;0.01$, Fig. 3).

Table 1: Weights (kg) of target shrimps and total by-catch species from 30 replicate tows, each from conventional codend (C) and modified codend (M) that was used in t-test comparison (M versus C; N=30; XP<0.05; XXP<0.01)

No of tows	Conventional Codend (C)		Modified Codend (M)	
	Target Shrimps	Total by-Catch	Target Shrimps	Total by-Catch Species
1	74.6	17.3	81.09	0.96
2	38	14.35	25.5	3.26
3	112.5	29.16	96.1	11.61
4	82.9	22.42	71	4.93
5	65.6	32.68	66.7	14.81
6	111	27.96	96	12.42
7	35.5	18.84	37	3.72
8	89	23.18	81.2	6.93
9	52.8	16.06	63.9	2.69
10	29.1	15.63	28.9	2.47
11	41.2	21.17	58.3	3.79
12	75	17.08	77.9	1.44
13	121	23.57	132	6.18
14	99.2	21.09	67	4.31
15	80.6	11.18	75.1	1.1
16	134	22.63	137.9	8.64
17	159	22.95	138	6.15
18	72.8	14.41	89	3.11
19	41	12.67	48	2.46
20	96	29.2	131.1	9.02
21	36.6	22.09	29.1	6.64
22	85.2	31.94	86.9	13.16
23	77	23.64	89	10.94
24	82	20.3	66.7	5.54
25	32.1	14.58	29	3.5
26	41.8	22.94	42.5	6.48
27	53	20.91	44	5.89
28	63	20.08	50.9	3.17
29	28.1	24.67	26.5	8.65
30	31	25.39	33.4	5.09
Total	2140.6	640.07	2079.69	179.06
Mean	71.35	21.33	69.32x	5.96x, xx
% Retention	100	100	97.1	27.94

Table 2: Weights (kg) of commercially important by-catch species from 30 replicate tows (N) from conventional codend (C) and modified codend (M) used for t – tests comparison (M versus C)

Name of Species	Family	C	M	Percentage Retention	Statistical Inference; XP<0.05 XXP<0.01 YP>0.05 YYP>0.01
Ilisha africana	Clupeidae	66.83	20.14	30.13	X,XX
Trichiurus lepturus	Trichiuridae	100.63	32.98	32.77	X,XX
Pseudotolithus elongatus	Sciaenidae	65.14	17.77	27.27	X,XX
Pseudotolithus senegalensis	Sciaenidae	82.62	27.56	33.35	X,XX
Pseudotolithus typus	Sciaenidae	84.37	26.72	31.67	X,XX
Epinephelus aenus	Serranidae	1.6	1.28	80.00	Y
Cynoglossus senegalensis	Cynoglossidae	26.39	3.89	14.74	X,XX
Drepane africana	Drepanidae	8.48	1.87	22.05	X,XX
Pentanemus quinquarius	Polynemidae	53.11	14.83	27.92	X,XX
Galeoides decadactylus	Polynemidae	40.97	8.51	20.77	X,XX
Sepia elegans	Sepiidae	5.31	1.55	29.19	X,XX
Callinectes amnicola	Portunidae	50.09	4.75	9.48	X,XX
Selene dorsalis	Carangidae	6.72	1.36	20.23	X,XX
Chloroscombrus chrysurus	Carangidae	9.08	2.05	22.57	X,XX
Lutjanus dentatus	Lutijanidae	12.03	1.72	14.29	X,XX
Dasyatis margarita	Dasyatidae	6.35	5.3	83.46	Y,YY
Carcharhinus brachyrus	Carcharhinidae	3.12	0.98	31.41	Y,YY
Pomadasys jubelini	Pomadasyidae	5.33	1.32	24.76	Y

Table 3: Summaries of one-tailed paired t-tests comparing the number of commercially important by-catch species from modified and conventional codends. M=Modified Codend; N= number of replicate; XXP <0.01; XP<0.05; YP > YYP>0.01

Name of Species	Family	Common Name	M versus conventional Paired T-Value (0.05)	P level	N
Ilisha africana	Clupeidae	African Shad	8.4543	X,XX	30
Trichiurus lepturus	Trichiuridae	Silver Fish	9.6096	X,XX	30
Pseudotolithus elongatus	Sciaenidae	Short Croaker	11.8254	X,XX	30
Pseudotolithus senegalensis	Sciaenidae	Normal Croaker	13.6801	X,XX	30
Pseudotolithus typus	Sciaenidae	Long Neck Croaker	10.593	X,XX	30
Epinephelus aenus	Serranidae	Grouper	1.1028	Y,YY	30
Cynoglossus senegalensis	Cynoglossidae	Sole Fish	5.7777	X,XX	30
Drepane africana	Drepanidae	Spade Fish	8.2725	X,XX	30
Pentanemus quinquarius	Polynemidae	Royal Thread	8.3897	X,XX	30
Galeoides decadactylus	Polynemidae	Shiny Nose	7.5247	X,XX	30
Callinectes amnicola	Portunidae	Blue Crab	9.8741	X,XX	30
Chloroscombrus chrysurus	Carangidae	Caranx	6.0382	X,XX	30
Selene dorsalis	Carangidae	Moon Fish	6.6609	X,XX	30
Lutjanus dentatus	Lutijanidae	Red Snapper	1.3779	Y,YY	30
Pomadasys jubelini	Pomadasyidae	Grunter	0.8965	Y,YY	30
Carcharhinus brachyrus	Carcharhinidae	Shark	0.9410	Y,YY	30
Sepia elegans	Sepiidae	Cuttle Fish	3.9911	X,XX	30
Dasyatis margarita	Dasyatidae	Ray Fish	0.9235	Y,YY	30

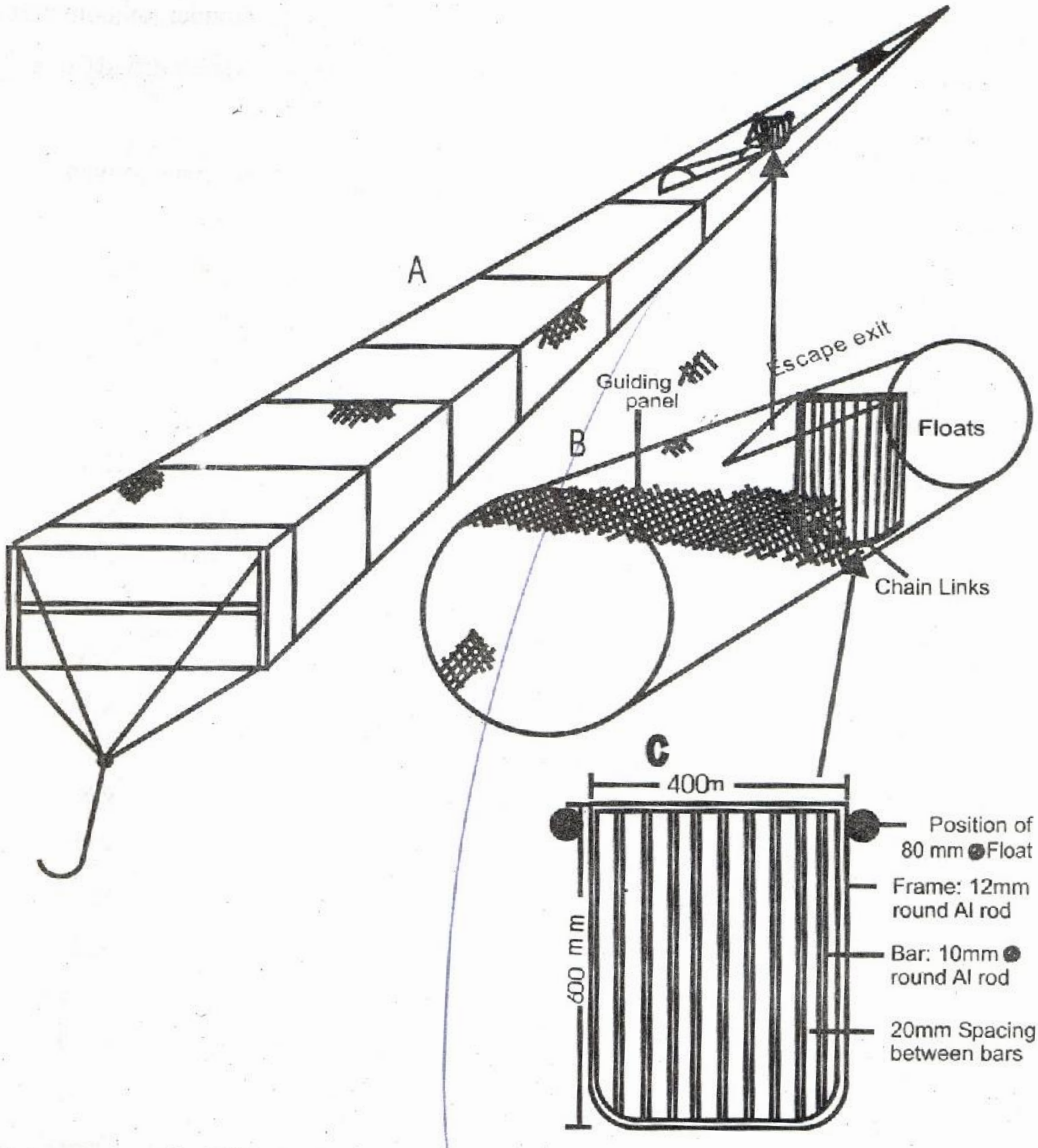

Fig. 1: Diagrammatic representation of;

(A) Rigid grid by- catch reduction device (BRD) installed at codend:
(B) Assembled rigid grid separator panel and
(C) Aluminium grid dimentions and float position.

dryer, dried better and faster than those dried on the bare floor in the open sun.

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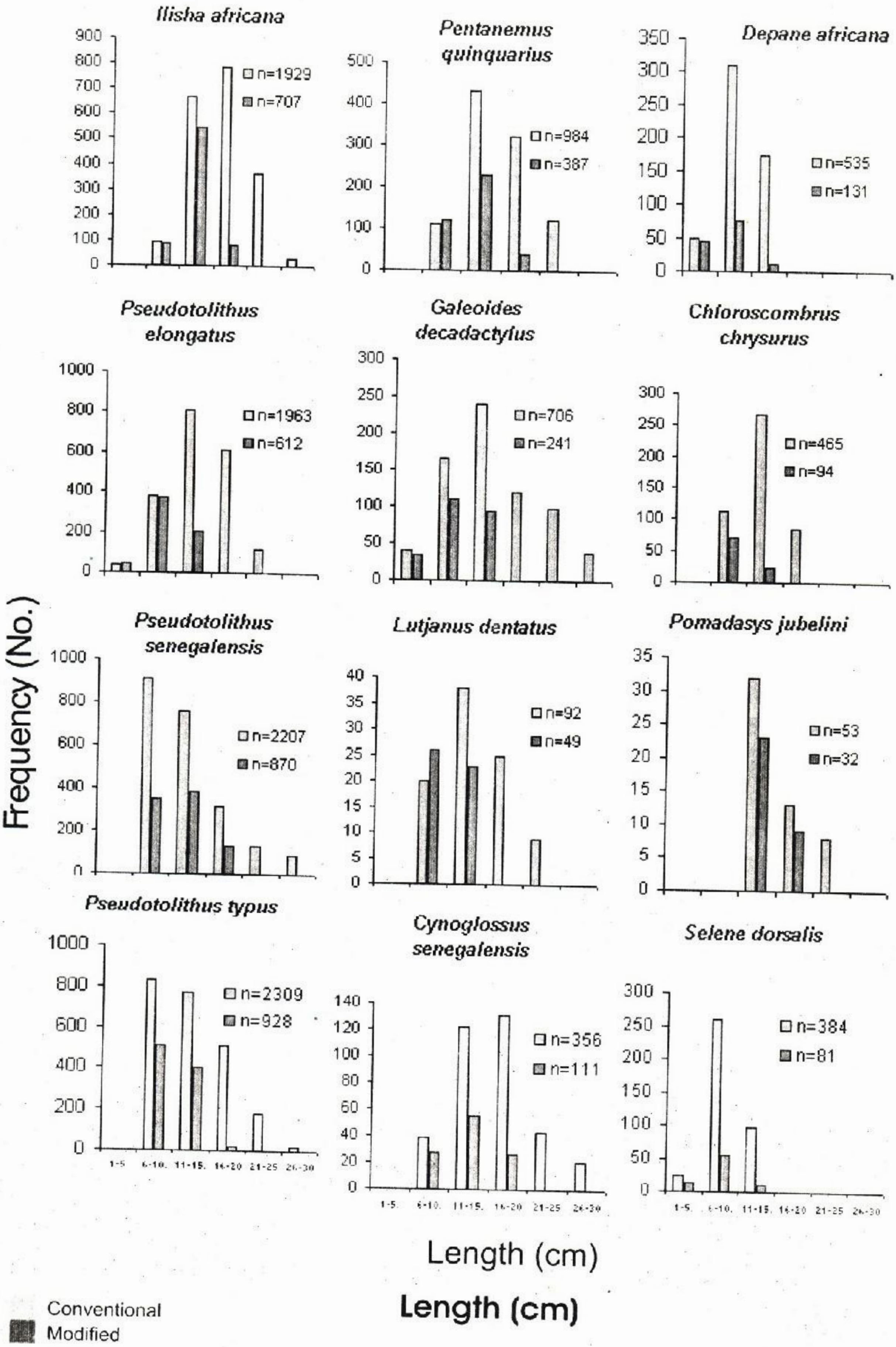

Fig 2: Size frequency distribution of important commercially by-catch species caught by conventional and modified codends

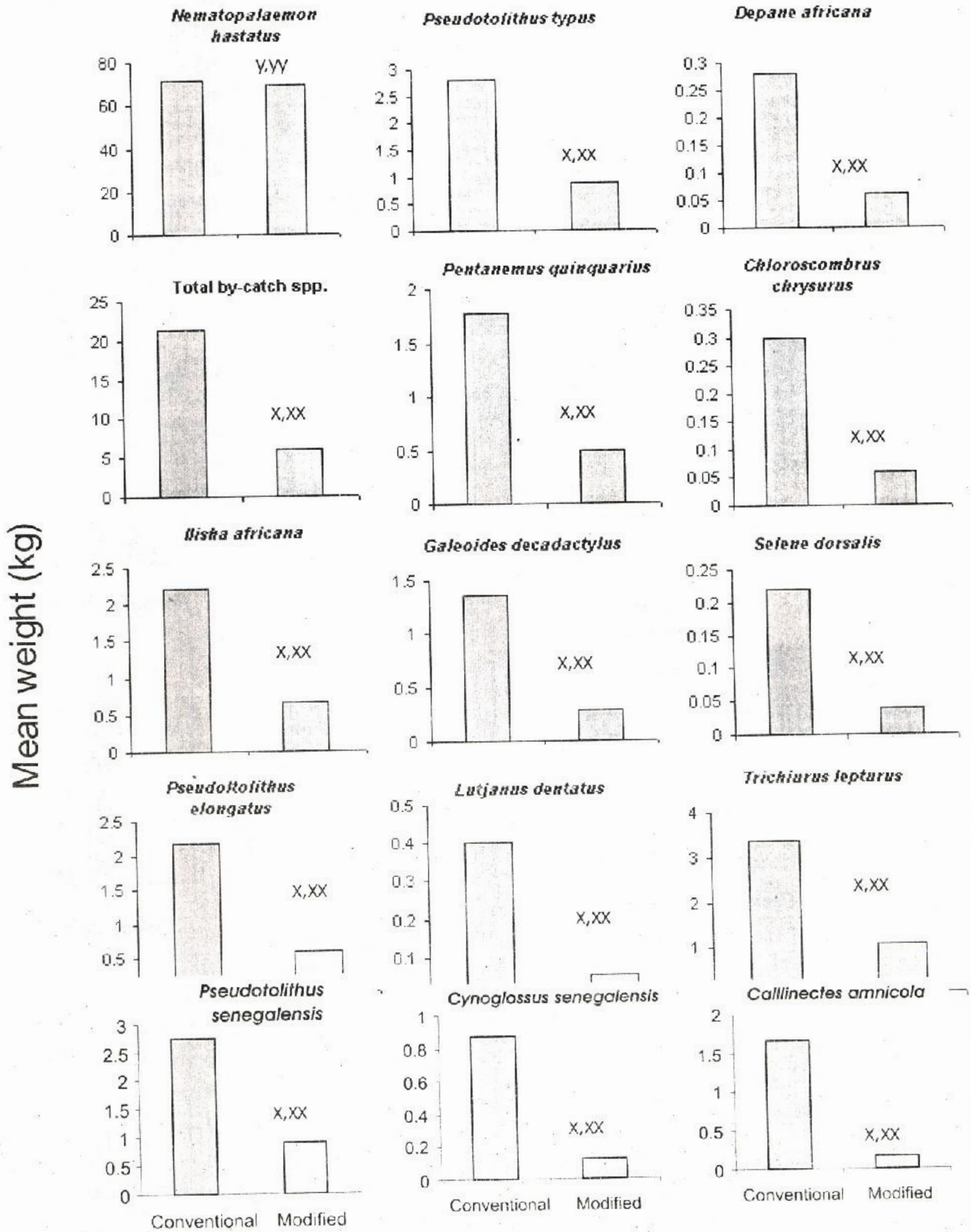

Fig 3: Differences in mean weight catches (per 2 hours tow) between conventional and modified codends.
Significance; xxp<0.01; xp<0.05, yyp>0.01, yp>0.05, N = 30

DISCUSSION

Coastal shrimp trawl by-catch in Nigeria and in fact, in developing countries has not attracted international attention and therefore is not being aggressively addressed by State and Federal management agencies. The local outcry about the unsustainable harvesting of juvenile fishes from fragile habitats (estuary, coastal seas) perceived to be the nursery ground for majority of fish species led to an observer study (Ambrose *et al,* 2005) and a successful development and introduction of gear modification capable of significantly reducing shrimp trawl by-catch and provided tools to more effectively manage and utilize coastal fishery resources.

Like other studies (Broadhurst *et al*, 1997; Kendal, 1990, Isaksen *et al,* 1992), this study has shown that there is great utility for the Nordmore grid in the conservation of 25 commercially important by-catch species (Ambrose *et a*l, 2005) and most abundance and prioritized croaker by-catch family, sciaenidae (Ambrose, 2004) incidentally killed in coastal shrimp trawls. The shrimp retention characteristics of the Nord more grid is attributed to its ability to remove jellyfish and marine debris more effectively, thus leading to high clean and quality shrimps. These were noticed at the end of two hourly tows. The design components enable the device to achieve these feats; the long guiding panel and smooth contours of the grid may have allowed the shrimps to detach from the jelly fish and thus enabled them to pass into the codend.

The low percentage in shrimps lost of 2.9% (Table 1) may promote its commercial application and endorsement by fishers, in contrast the high percentage reduction of commercially important by-catch species of 72.06% (Table 1) especially large sizes of total length 11-30cm (Fig. 2) make fishers skeptical in its wide spread adoption. Ambrose *et al* (2005) have earlier reported that by-catch from this fishery falls within a total length range of 4-30cm, length range of 11-30cm are marketable and consumed while length range of 4-10cm are discarded ashore. Based on catch utilization, the result therefore brings different perception to different professional stake holders in shrimp fisheries resources. To the Economists and fishes themselves, it is a loss of income while to the Biologist, and Environmentalist it is conservative.

Nordmore grid, with bar spacing of 20 mm retained nearly all species with total length of 4-10cm while most fishes with total length of 11-30cm were excluded because it could not pass through the 20mm bar spacing of Nordmore grid to the codend. The implications are that marketable sizes of fishes are lost while at the same time small sizes of fishes are killed incidentally. Since the percentage of shrimp retained is more (97.1%) it could be better to ignore the quantity of fish killed. Alternatively, secondary by-catch reducing device like square mesh panel or fish eye could be installed to further reduce the quantity of juveniles (4 – 10cm TL) retained in the fishery studied as reported in Australia (Broadhurst et al, 1997). The Nordmore grid therefore has a great potential in by-catch reduction in the fishery but with anticipated by-catch livelihood trades termination and lost of income to fishers. Further refinements of the design of the grid assemblage for example; increase in the bar spacing of grid from 20mm to 40 mm will allowed the retention of large sized fish for commercial use as well as incorporation of secondary BRD to facilitate the escape of small sized fish to grow and be recruited into the fishery in future years.

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